Published in final edited form as:

Ann Epidemiol. 2015 October ; 25(10): 760–766.e2. doi:10.1016/j.annepidem.2015.06.081.

CHILDHOOD ABUSE VICTIMIZATION, STRESS-RELATED EATING, AND WEIGHT STATUS IN YOUNG WOMEN

Susan M. Mason, PhD^{a,b}, Richard F. MacLehose, PhD^a, Sabra L. Katz-Wise, PhD^c, S. Bryn Austin, ScD^{b,c}, Dianne Neumark-Sztainer, PhD^a, Bernard L. Harlow, PhD^a, and Janet W. Rich-Edwards, ScD^{d,e}

^aDivision of Epidemiology and Community Health, University of Minnesota School of Public Health, 1300 South 2nd Street, Minneapolis, MN 55454

^bChanning Division of Network Medicine, Brigham and Women's Hospital and Harvard Medical School, 181 Longwood Ave, Boston, MA 02115

^cDivision of Adolescent and Young Adult Medicine, Boston Children's Hospital, 300 Longwood Ave, Boston, MA 02115/Department of Pediatrics, Harvard Medical School, Boston, MA

^dConnors Center for Women's Health and Gender Biology, Brigham and Women's Hospital and Harvard Medical School, 1620 Tremont St, Boston, MA 02130

^eDepartment of Epidemiology, Harvard School of Public Health, Boston, MA

Abstract

Purpose—Abuse in childhood predicts stress-related overeating and excess weight gain in young women. We investigated whether two stress-related overeating behaviors—binge eating and coping-motivated eating—explain childhood abuse associations with weight status in young women.

Methods—Analyses included 4377 women participating in the Growing Up Today Study (GUTS), a longitudinal cohort of youth enrolled at age 9–14 years. We used marginal structural models to estimate the effects of abuse prior to age 11 years on weight status at age 22–29 years with and without adjustment for binge eating and coping-motivated eating.

Corresponding Author: Susan M. Mason, Division of Epidemiology and Community Health, University of Minnesota, 1300 South 2nd Street, 3rd Floor, Minneapolis, MN 55454, smmason@umn.edu, 612-624-9556.

Conflicts of interest: The authors have no conflicts of interest relevant to this article to disclose.

Author contributions:

Susan M. Mason conceptualized and designed the study, carried out analyses, drafted the initial manuscript, and approved the final manuscript as submitted.

Richard F. MacLehose contributed to the conceptualization and design, provided statistical consulting, reviewed and revised the manuscript, and approved the final manuscript as submitted.

Bernie L. Harlow, Dianne Neumark-Sztainer, and Sabra L. Katz-Wise contributed to the conceptualization and design, reviewed and revised the manuscript, and approved the final manuscript as submitted.

S. Bryn Austin and Janet Rich-Edwards were involved in data collection, contributed to the conceptualization and design of the study, reviewed and revised the manuscript, and approved the final manuscript as submitted.

The content is solely the responsibility of the authors and does not necessarily represent the office views of the NICHD or NIH.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Results—Women with severe physical, sexual, and emotional abuse had early adult body mass indexes (BMI) that were 0.74 kg/m² (95% CI: 0.15, 1.33), 0.69 (95% CI: −0.46, 1.83), and 0.85 (95% CI: 0.24, 1.45) kg/m² higher, respectively, than those without abuse. Adjustment for coping-motivated eating attenuated the excess BMI associated with severe physical abuse, but no other important attenuations were found.

Conclusions—Physical, sexual, and emotional abuse prior to age 11 years were associated with higher early adult weight status, though the sexual abuse estimate was not statistically significant. Evidence for a role of stress-related eating in abuse–BMI associations was limited and inconsistent across abuse types.

Keywords

Child Abuse; Violence; Psychological Stress; Hyperphagia; Eating Disorders; Overweight; Obesity; Body Mass Index

Introduction

National surveys indicate that over 30% of women in the US experienced physical or sexual abuse in childhood or adolescence [1,2]. Abuse affects psychological and social well-being [3], and may also predict subsequent obesity [4–15], particularly in girls and women [7,14]. High-quality replications of the abuse–obesity association are needed, as are investigations of potential intermediates on the abuse–weight status pathway that could guide development of interventions to prevent excess weight gain in abused populations. While primary abuse prevention is the gold standard for averting abuse-related health consequences, these programs currently have imperfect reach and effectiveness [16]. Development of strategies to prevent obesity in women with abuse histories is an important complementary effort that requires identification of potential targets for intervention on the causal pathway between abuse and weight gain.

The mechanisms behind the abuse–weight gain association have remained largely unexplored, but several lines of evidence suggest a pathway through stress-related disordered eating behaviors. Childhood abuse has been repeatedly found to be associated with disordered eating behaviors relevant to obesity, such as binge eating [17–19]. Moreover, animal and clinical research indicates that exposure to stress can trigger overeating of palatable comfort foods [20–22], which can provide short-term relief from distress by stimulating brain reward systems [23,24]. Despite the evidence linking childhood abuse to both disordered eating and obesity, little work has been done to estimate the extent to which abuse-related weight gain is explained by stress-related eating behaviors [8].

In this study, we sought to replicate the abuse–weight status association among women in early adulthood and to investigate the extent to which this impact might be explained by stress-related disordered eating behaviors. We focus on women in this study because of the stronger evidence for an association between abuse and obesity, as well as the higher prevalence of stress-related overeating, in women versus men [25].

Material and methods

Sample

The Growing Up Today Study (GUTS) comprises children of participants in the Nurses' Health Study II (NHSII), a longitudinal cohort of female registered nurses. In 1996, NHSII participants with children aged 9–14 years were asked to provide consent for their children to participate in GUTS; 18,526 mothers (54%) consented, and their children (n=26,765) were invited to participate. Of these, 16,882 returned the baseline questionnaire and have been followed using annual and biennial questionnaires. Participants were aged 22 to 29 years in 2010, the most recent fully completed data collection cycle.

This analysis included female participants (n=9,039 at baseline). Participants were excluded if they did not complete the long form of the 2007 GUTS questionnaire on abuse history (n=3133). A comparison of baseline characteristics between participants who filled out the 2007 questionnaire and those who did not is provided as Supplementary Information (Table S1). For our analytic sample, we additionally excluded those who had no data on the outcome of interest (BMI in 2010; n=982), or were missing key sociodemographic and maternal covariates (n=547). This left 4377 women for our analysis.

Variables

Exposure—In 2007, the GUTS survey included questions on physical, sexual, and emotional abuse during childhood (age 0–10 years) and adolescence (age 11–17 years). We focused our analysis on abuse in childhood (before age 11 years), prior to typical age of disordered eating onset [26].

Physical abuse was assessed with items from the Conflict Tactics Scales [27], which asked participants “how often did an adult in your family push, grab or shove you?” and “how often did an adult in your family kick, punch or hit you with something in a way that hurt your body, or physically attack you in some other way?” Physical abuse was categorized as none, mild (pushed/shoved but not kicked/punched/physically attacked), or severe (kicked/punched/physically attacked).

Sexual abuse was ascertained with questions with the following questions initially used by Finkelhor et al. [28]: “When you were a child (before age 11) were you touched in a sexual way by an adult or older child or were you forced to touch an adult or older child in a sexual way when you did not want to?” and “When you were a child (before age 11) did an adult or older child force you or attempt to force you into any sexual activity by threatening you, holding you down or hurting you in some way when you did not want to?” We categorized sexual abuse as none, sexual touching only, and forced sexual activity.

Emotional abuse was measured with three items from the Childhood Trauma Questionnaire [29] asking participants how often (never to very often) an adult in their family yelled and screamed at them, said hurtful or insulting things to them, or punished them in a way that seemed cruel. The CTQ has been found to perform well across a variety of populations [30]. The sum of these Likert scores was categorized into three levels to parallel the structure of physical and emotional abuse. We chose cut-offs that reflect the prevalence of moderate and

severe abuse severity observed in other cohorts [31,32]: least abusive (below the 75th percentile), more abusive (75th–90th percentile), and most abusive (>90th percentile).

Outcome—Body Mass Index (BMI) in kg/m² was based on self-reported weight and height in 2010 (age 22–29 years). Self-reports of height and weight have been shown to have good validity in several cohorts [33,34].

History of binge eating—Binge eating was assessed on 10 questionnaires from 1996 through 2010. Participants were asked to report whether, over the past year, they went on an “eating binge,” defined as eating “an amount of food that most people... would consider very large.” Participants were then asked to report whether they felt out of control during the eating binge. A history of binge eating was defined as reported binge eating with loss of control on any questionnaire from baseline through 2010.

Coping-motivated eating—In 2010, the questionnaire included the Coping-Motivated Eating subscale of the Motivations to Eat Scale [35], which ascertains the frequency (almost never to almost always) with which respondents eat in order to cope with negative feelings, to comfort themselves, or to distract themselves from unpleasant thoughts. The scale is calculated by summing Likert scores. We divided the scale into quartiles to account for a non-linear association with the outcome.

Covariates—We adjusted for potential confounders of the abuse–weight status association, including demographic and socioeconomic factors (age at 1996 baseline in years, nonwhite race, and perceived social status score), weight status at study baseline (participant’s baseline BMI standardized to Centers for Disease Control and Prevention growth chart data [36]), and maternal risk factors for abuse and/or obesity in her children [37] (mother’s self-reported history of antidepressant use and BMI at age 18 years, both obtained from NHSII questionnaires). Models assessing the role of eating behaviors were additionally adjusted for potential confounders of the eating behavior–weight status association [38] including smoking (yes/no), dieting (yes/no), physical activity dichotomized at the baseline median (indicator for 10+ hours/week of physical activity) and depression (McKnight Risk Factor Surveillance Survey [39] and Center for Epidemiologic Studies Depression Scale—Short Form [40] scores).

Data analysis

Childhood abuse–eating behavior and eating behavior–weight status

associations—Based on our hypothesized causal pathway (Figure 1), we assessed individual associations between (1) abuse and stress-related eating, and (2) stress-related eating and BMI. We used modified Poisson marginal structural models (MSMs) [41,42] with inverse probability of exposure weights [42,43] to estimate covariate-adjusted risk ratios for binge eating and top quartile of coping-motivated eating as functions of abuse. We used linear MSMs to estimate covariate-adjusted differences in BMI as a function of history of binge eating and (in separate models) top quartile of coping-motivated eating. Details of the modeling approach can be found in Appendix S1. Robust standard errors were computed for all estimates. Analyses were conducted in SAS 9.3 (Cary, NC).

Childhood abuse, eating behavior, and weight status: total and controlled

direct effects—We then estimated the association between childhood abuse and BMI in 2010, as well as the abuse–BMI associations adjusted for eating behaviors thought to lie on the causal pathway (Figure 1). The first association, known as the “total effect” [38], estimates the impact of abuse on early adult BMI that occurs *through any pathway*. The second association, known as the “controlled direct effect” (CDE) [38] estimates the impact of abuse on BMI *through pathways that do not involve the eating behavior of interest* and provides an approximation of the remaining impact of abuse on BMI if one were to intervene to prevent abuse-related binge eating or coping-motivated eating.

To estimate total effects, we used linear MSMs, regressing BMI at age 22–29 years on indicators for severity of physical, sexual, and emotional abuse prior to age 11 years in separate models. For each type of abuse, we first fit a crude model and then added inverse probability of exposure weights adjusting for covariates in the following sequence: sociodemographic factors (age, race); maternal BMI at age 18 years; perceived social status; mother’s history of antidepressant use; and participant weight status at study baseline. Finally, we estimated the unique contribution of each type of abuse to early adult BMI by adjusting for the other types of abuse. Because this mutual adjustment substantially reduced precision of the estimates, subsequent analyses were not mutually adjusted. To assess the impact of adolescent abuse, which we did not include in our exposure measure in our main analyses, we ran supplemental models of the abuse–BMI association with abuse defined using the most severe event in either childhood or adolescence.

CDEs adjusted for binge eating: To estimate the CDE of abuse on BMI controlling for binge eating history, we regressed BMI in 2010 on abuse exposure and history of binge eating using inverse probability weights to adjust for abuse–BMI confounders and binge eating–BMI confounders. Preliminary physical and sexual abuse results indicated that only severe exposure had an important impact on weight change; we therefore dichotomized physical and sexual abuse as severe versus none/mild for our physical and sexual abuse analyses. We also assessed the joint impact of multiple types of abuse using indicators for no abuse (referent), any type of mild abuse, one type of severe abuse, and two or more types of severe abuse. We also tested for an interaction between abuse and binge eating [38].

CDEs adjusted for coping-motivated eating: To estimate the CDE of abuse on BMI controlling for coping-motivated eating, we regressed BMI in 2010 on abuse exposure and coping-motivated eating in quartiles, using inverse probability weights to adjust for potential confounders. We tested for an interaction between abuse and coping-motivated eating. We also ran a set of supplemental models adjusted for a 4-category joint binge eating and top-quartile of coping-motivated variable categorized as: neither coping-motivated eating nor binge eating, binge eating alone, coping-motivated eating alone, and coping-motivated eating plus binge eating.

Results

Of our sample of 4377 women, just over 45% reported some form of physical, sexual, or emotional abuse prior to age 11 years (Table 1a). Approximately 15% of the sample

reported one or more types of severe abuse in childhood and 5% reported two or more types of severe abuse. Maternal history of antidepressant use, participant history of smoking, and participant depression score were higher in those with greater abuse severity (Table 1b).

Childhood abuse and eating behaviors

Adjusted risk ratios (RRs) for binge eating associated with severe physical, sexual, and emotional abuse, relative to no abuse, were 1.44 (95% CI: 1.26, 1.66), 1.31 (95% CI: 1.00, 1.72), and 1.52 (95% CI: 1.32, 1.75), respectively (Table S2). Adjusted RRs of top-quartile coping-motivated eating were 1.43 (95% CI: 1.20, 1.70), 1.51 (95% CI: 1.13, 2.01), and 1.47 (95% CI: 1.23, 1.76), for severe physical, sexual, and emotional abuse, respectively (Table S2).

Eating behaviors and BMI

History of binge eating was associated with an adjusted BMI difference of 0.39 kg/m² (95% CI: 0.04, 0.75) at age 22–29 years relative to no binge eating (Table S3). The top quartile of coping-motivated eating was associated with an adjusted BMI difference of 2.36 kg/m² (95% CI: 1.89, 2.83) relative to the bottom three quartiles (Table S3).

Abuse and BMI: Total effects

Severe physical, sexual, and emotional abuse in childhood were associated with crude differences in BMI, relative to no abuse, of 1.30 kg/m² (95% CI: 0.68, 1.93), 1.22 kg/m² (95% CI: -0.01, 2.45), and 1.70 kg/m² (95% CI: 1.06, 2.35), respectively (Table 2a). After full adjustment, these abuse-associated BMI differences were attenuated to 0.74 kg/m² (95% CI: 0.15, 1.33), 0.69 kg/m² (95% CI: -0.46, 1.83), and 0.85 kg/m² (95% CI: 0.24, 1.45), respectively. Adjustment for baseline BMI was largely responsible for these attenuations. Mild physical and sexual abuse were unrelated to weight status, but mild emotional abuse was associated with an adjusted BMI difference of 0.39 kg/m² (95% CI: 0.01, 0.78). In models mutually adjusted for different types of abuse, emotional abuse retained its association with BMI, while the other types of abuse were attenuated, suggesting that emotional abuse might be the major driver of weight status (Table 2b), but wide confidence intervals prevent strong conclusions. Inclusion of adolescent abuse in our supplemental analyses strengthened the association of physical abuse with BMI, while the emotional abuse association remained largely the same (Table S4). The childhood-adolescent sexual abuse association with BMI was attenuated compared to estimates from main analyses of childhood abuse alone.

Analyses of exposure to multiple types of abuse suggested an additive impact (Table 3a): relative to no abuse, one type of severe abuse was associated with a difference in BMI of 0.51 kg/m² (95% CI: -0.12, 1.15), while two or more types of severe abuse were associated with a BMI difference of 1.09 kg/m² (95% CI: 0.29, 1.89).

Controlled direct effects

We expected that adjustment for eating behaviors would substantially diminish associations between abuse and BMI, but we did not observe this (Tables 3a and 3b). Adjustment for a history of binge eating reduced the excess BMI associated with severe sexual abuse from

0.74 (95% CI: -0.48, 1.95) to 0.50 (95% CI: -0.95, 1.95), but this difference may simply reflect random error. Adjusting for binge eating did not attenuate physical or emotional abuse estimates. Adjustment for coping-motivated eating had a substantial impact on the physical abuse-BMI estimate, reducing it from 0.63 (95% CI: 0.04, 1.23) to 0.35 (95% CI: -0.28, 0.98), but had no such impact on sexual or emotional abuse estimates. Adjustment for the combination of coping-motivated eating and binge eating had no impact beyond adjustment for coping-motivated eating alone.

Discussion

Our study adds to a growing body of literature suggesting that childhood abuse leads to excess weight gain in early adulthood [7,11,13]. The 15% of young women in our study sample with a history of severe physical, sexual, or emotional abuse in childhood were roughly three quarters of one unit of BMI heavier in early adulthood than their non-abused counterparts, although the estimate for sexual abuse was imprecise. The 5% who were exposed to two or more types of severe abuse were over one unit of BMI heavier. While abuse-related BMI differences of this magnitude will have only a modest impact on any individual's health at any given time, at a population level—and over the life course—the accumulated impact may be significant. Furthermore, these differences reflect diverging BMI trajectories measured at the beginning of adulthood; if these trajectories continue to diverge, BMI differences may become much more pronounced with age. These findings highlight the urgent need for effective strategies to both prevent abuse and optimize the health of abused populations in cases where prevention has failed.

In prior work we found childhood abuse to be associated with an almost two-fold increased risk of food addiction [19], in line with other studies showing an association between abuse and binge eating [17,18]. We therefore hypothesized that one way to prevent abuse-related obesity might be to intervene on abuse-related eating behaviors that are relevant to obesity. We found some evidence that prevention of coping-motivated eating might reduce physical abuse-related weight gain. However, the same impact was not observed for emotional abuse. In mutually adjusted models, emotional abuse was more strongly associated with BMI than physical or sexual abuse, and thus the lack of evidence for a role for stress-related eating in the emotional abuse-BMI link is important to note and suggests that intervening to prevent excess binge eating or coping-motivated eating—though potentially worthwhile for other reasons—is likely to be only modestly effective at reducing abuse-related excess weight gain.

Two other published studies have previously examined the role of stress-related eating behaviors in the association between exposure to violence and obesity, both finding that regression-based adjustment for stress-related eating slightly attenuated the violence-obesity odds ratio for middle-age women [8,15]. These results, like ours, suggest that intervention on stress-related eating would have at most a small impact on violence-associated obesity.

As with all observational research, omission of important unknown confounders in our models could have resulted in biased estimates. Like most epidemiologic studies of abuse [10,11], we relied on retrospective abuse recall up to 25 years after exposure, which may

have resulted in misclassification especially of more moderate levels of abuse. Measures of eating behavior were necessarily brief given the large epidemiologic nature of the study; error in eating behavior measures could have diluted the impact of their adjustment on the abuse–BMI effect estimates. Finally, the GUTS cohort is a highly select sample of mostly white young adults and the cohort suffered significant attrition over the first several years of follow-up. Nonetheless, the primary associations observed should be internally valid and likely reflect mechanisms that are generalizable across populations.

Our study has several notable strengths, including the application of MSMs, which allow for estimation of the impact of intervention on one factor (e.g. stress-related eating) while appropriately adjusting for the confounding influence of other related factors (e.g. depression, dieting) that may also occur on the pathway from abuse to weight status [38]. Our study data had rich time-varying information on binge eating and weight status, as well as a large sample size. Our aim was to clarify the role of two eating behaviors that appeared, based on available evidence, to be promising targets for health behavior intervention. Our findings highlight the need for careful empirical investigations that explicitly examine hypothesized pathways, and the utility of observational data for providing early evidence for or against a hypothesized mechanism. While this observation approach does not take the place of randomized controlled intervention trials, it can help to target those trials toward hypotheses with greater potential for success.

Our findings indicate that abuse predicts excess weight gain in a substantial minority of young women. Although we had hypothesized that stress-related eating behaviors might be one promising target for intervention in this population, our results provide only limited support for this idea. Future research should investigate other eating behavior phenotypes that may contribute to abuse-related obesity, as well as non-eating-behavior pathways between abuse and obesity.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Funding source:

Research is supported by the Building Interdisciplinary Research Careers in Women's Health Grant (# K12HD055887) from the Eunice Kennedy Shriver National Institutes of Child Health and Human Development (NICHD), the Office of Research on Women's Health, and the National Institute on Aging, NIH, administered by the University of Minnesota Deborah E. Powell Center for Women's Health.

Abbreviations

BMI	Body Mass Index
MSM	Marginal Structural Model
RR	Risk Ratio
CI	Confidence Interval

References

1. Tjaden, P.; Thoennes, N. Prevalence, incidence, and consequences of violence against women: findings from the National Violence Against Women Survey. Washington, DC: US Department of Justice; 2000.
2. Black, M.; Basile, K.; Breiding, M.; Smith, S.; Walters, M.; Merrick, M., et al. The National Intimate Partner and Sexual Violence Survey (NISVS): 2010 Summary Report. Atlanta, GA: National Center for Injury Prevention and Control, Centers for Disease Control and Prevention; 2011.
3. Buckingham ET, Daniolos P. Longitudinal outcomes for victims of child abuse. *Curr Psychiatry Rep.* 2013;15.10.1007/s11920-012-0342-3
4. Felitti VJ. Childhood sexual abuse, depression, and family dysfunction in adult obese patients: a case control study. *South Med J.* 1993; 86:732–6. [PubMed: 8322078]
5. Lissau I, Sørensen TI. Parental neglect during childhood and increased risk of obesity in young adulthood. *Lancet.* 1994; 343:324–7.10.1016/S0140-6736(94)91163-0 [PubMed: 7905145]
6. Alvarez J, Pavao J, Baumrind N, Kimerling R. The Relationship Between Child Abuse and Adult Obesity Among California Women. *Am J Prev Med.* 2007; 33:28–33.10.1016/j.amepre.2007.02.036 [PubMed: 17572308]
7. Mamun AA, Lawlor DA, O’Callaghan MJ, Bor W, Williams GM, Najman JM. Does childhood sexual abuse predict young adult’s BMI? A birth cohort study. *Obesity (Silver Spring).* 2007; 15:2103–10.10.1038/oby.2007.250 [PubMed: 17712129]
8. Greenfield EA, Marks NF. Violence from parents in childhood and obesity in adulthood: Using food in response to stress as a mediator of risk. *Soc Sci Med.* 2009; 68:791–8.10.1016/j.socscimed.2008.12.004 [PubMed: 19185965]
9. Bentley T, Widom CS. A 30-year follow-up of the effects of child abuse and neglect on obesity in adulthood. *Obesity (Silver Spring).* 2009; 17:1900–5.10.1038/oby.2009.160 [PubMed: 19478789]
10. Boynton-Jarrett R, Rosenberg L, Palmer JR, Boggs DA, Wise LA. Child and Adolescent Abuse in Relation to Obesity in Adulthood: The Black Women’s Health Study. *Pediatrics.* 2012; 130:245–53.10.1542/peds.2011-1554 [PubMed: 22753562]
11. Shin SH, Miller DP. A longitudinal examination of childhood maltreatment and adolescent obesity: Results from the National Longitudinal Study of Adolescent Health (Add Health) Study. *Child Abuse Negl.* 2012; 36:84–94.10.1016/j.chiabu.2011.08.007 [PubMed: 22398304]
12. Afifi TO, Mota N, MacMillan HL, Sareen J. Harsh physical punishment in childhood and adult physical health. *Pediatrics.* 2013; 132:e333–40.10.1542/peds.2012-4021 [PubMed: 23858428]
13. Noll JG, Zeller MH, Trickett PK, Putnam FW. Obesity risk for female victims of childhood sexual abuse: a prospective study. *Pediatrics.* 2007; 120:e61–7.10.1542/peds.2006-3058 [PubMed: 17606550]
14. Fuller-Thomson E, Sinclair DA, Brennenstuhl S. Carrying the pain of abuse: Gender-specific findings on the relationship between childhood physical abuse and obesity in adulthood. *Obes Facts.* 2013; 6:325–36.10.1159/000354609 [PubMed: 23970142]
15. Rohde P, Ichikawa L, Simon GE, Ludman EJ, Linde JA, Jeffery RW, et al. Associations of child sexual and physical abuse with obesity and depression in middle-aged women. *Child Abuse Negl.* 2008; 32:878–87.10.1016/j.chiabu.2007.11.004 [PubMed: 18945487]
16. Barlow J, Johnston I, Kendrick D, Polnay L, Stewart-Brown S. Individual and group-based parenting programmes for the treatment of physical child abuse and neglect. *Cochrane Database Syst Rev.* 2006; 3:CD005463.10.1002/14651858.CD005463.pub2 [PubMed: 16856097]
17. Chen LP, Murad MH, Paras ML, Colbenson KM, Sattler AL, Goranson EN, et al. Sexual Abuse and Lifetime Diagnosis of Psychiatric Disorders: Systematic Review and Meta-analysis. *Mayo Clin Proc.* 2010; 85:618–29.10.4065/mcp.2009.0583 [PubMed: 20458101]
18. Fischer S, Stojek M, Hartzell E. Effects of multiple forms of childhood abuse and adult sexual assault on current eating disorder symptoms. *Eat Behav.* 2010; 11:190–2.10.1016/j.eatbeh.2010.01.001 [PubMed: 20434068]

19. Mason SM, Flint AJ, Field AE, Austin SB, Rich-Edwards JW. Abuse victimization in childhood or adolescence and risk of food addiction in adult women. *Obesity (Silver Spring)*. 2013; 200:1–33.10.1002/oby.20500
20. Rowland NE, Antelman SM. Stress-induced hyperphagia and obesity in rats: a possible model for understanding human obesity. *Science*. 1976; 191:310–2. [PubMed: 1246617]
21. Dallman MF, Pecoraro N, Akana SF, La Fleur SE, Gomez F, Houshyar H, et al. Chronic stress and obesity: a new view of “comfort food”. *Proc Natl Acad Sci U S A*. 2003; 100:11696–701.10.1073/pnas.1934666100 [PubMed: 12975524]
22. Wilson ME, Fisher J, Fischer A, Lee V, Harris RB, Bartness TJ. Quantifying food intake in socially housed monkeys: Social status effects on caloric consumption. *Physiol Behav*. 2008; 94:586–94.10.1016/j.physbeh.2008.03.019 [PubMed: 18486158]
23. Ulrich-Lai YM, Christiansen AM, Ostrander MM, Jones AA, Jones KR, Choi DC, et al. Pleasurable behaviors reduce stress via brain reward pathways. *Proc Natl Acad Sci U S A*. 2010; 107:20529–34.10.1073/pnas.1007740107 [PubMed: 21059919]
24. Tomiyama AJ, Dallman MF, Epel ES. Comfort food is comforting to those most stressed: Evidence of the chronic stress response network in high stress women. *Psychoneuroendocrinology*. 2011; 36:1513–9.10.1016/j.psyneuen.2011.04.005 [PubMed: 21906885]
25. Jääskeläinen A, Nevanperä N, Remes J, Rahkonen F, Järvelin M-R, Laitinen J. Stress-related eating, obesity and associated behavioural traits in adolescents: a prospective population-based cohort study. *BMC Public Health*. 2014; 14:321.10.1186/1471-2458-14-321 [PubMed: 24708823]
26. Kessler RC, Berglund Pa, Chiu WT, Deitz AC, Hudson JI, Shahly V, et al. The prevalence and correlates of binge eating disorder in the World Health Organization World Mental Health Surveys. *Biol Psychiatry*. 2013; 73:904–14.10.1016/j.biopsych.2012.11.020 [PubMed: 23290497]
27. Strauss, MA.; Gelles, RJ. *Physical Violence in American Families: Risk Factors and Adaptations to Violence in 8,145 Families*. New Brunswick: Transaction Publishers; 1990.
28. Finkelhor D, Moore D, Hamby SL, Straus MA. Sexually abused children in a national survey of parents: methodological issues. *Child Abuse Negl*. 1997; 21:1–9.10.1016/S0145-2134(96)00127-5 [PubMed: 9023018]
29. Bernstein DP, Fink L, Handelsman L, Foote J, Lovejoy M, Wenzel K, et al. Initial reliability and validity of a new retrospective measure of child abuse and neglect. *Am J Psychiatry*. 1994; 151:1132–6. [PubMed: 8037246]
30. Scher CD, Stein MB, Asmundson GJ, McCreary DR, Forde DR. The childhood trauma questionnaire in a community sample: psychometric properties and normative data. *J Trauma Stress*. 2001; 14:843–57.10.1023/A:1013058625719 [PubMed: 11776429]
31. Felitti VJ, Anda RF, Nordenberg D, Williamson DF, Spitz AM, Edwards V, et al. Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults. The Adverse Childhood Experiences (ACE) Study. *Am J Prev Med*. 1998; 14:245–58.10.1016/S0749-3797(98)00017-8 [PubMed: 9635069]
32. Rich-Edwards JW, Mason S, Rexrode K, Spiegelman D, Hibert E, Kawachi I, et al. Physical and Sexual Abuse in Childhood as Predictors of Early-Onset Cardiovascular Events in Women. *Circulation*. 2012; 126:920–7.10.1161/CIRCULATIONAHA.111.076877 [PubMed: 22787111]
33. Strauss RS. Comparison of measured and self-reported weight and height in a cross-sectional sample of young adolescents. *Int J Obes Relat Metab Disord*. 1999; 23:904–8.10.1038/sj.ijo.0800971 [PubMed: 10490794]
34. Goodman E, Hinden BR, Khandelwal S. Accuracy of teen and parental reports of obesity and body mass index. *Pediatrics*. 2000; 106:52–8.10.1542/peds.106.1.52 [PubMed: 10878149]
35. Jackson B, Cooper ML, Mintz L, Albino A. Motivations to eat: Scale development and validation. *J Res Pers*. 2003; 37:297–318.10.1016/S0092-6566(02)00574-3
36. Kuczmarski RJ, Ogden CL, Guo SS, Grummer-Strawn LM, Flegal KM, Mei Z, et al. 2000 CDC Growth Charts for the United States: methods and development. *Vital Health Stat*. 2002; 11:1–190.
37. Conron KJ, Beardslee W, Koenen KC, Buka SL, Gortmaker SL. A longitudinal study of maternal depression and child maltreatment in a national sample of families investigated by child protective

- services. *Arch Pediatr Adolesc Med*. 2009; 163:922–30.10.1001/archpediatrics.2009.176 [PubMed: 19805711]
38. VanderWeele TJ. Marginal Structural Models for the Estimation of Direct and Indirect Effects. *Epidemiology*. 2009; 20:18–26.10.1097/EDE.0b013e31818f69ce [PubMed: 19234398]
39. Shisslak CM, Renger R, Sharpe T, Crago M, McKnight KM, Gray N, et al. Development and evaluation of the McKnight Risk Factor Survey for assessing potential risk and protective factors for disordered eating in preadolescent and adolescent girls. *Int J Eat Disord*. 1999; 25:195–214.10.1002/(SICI)1098-108X(199903)25:2<195::AID-EAT9>3.0.CO;2-B [PubMed: 10065397]
40. Andresen EM, Malmgren JA, Carter WB, Patrick DL. Screening for depression in well older adults: Evaluation of a short form of the CES-D. *Am J Prev Med*. 1994; 10:77–84. [PubMed: 8037935]
41. Zou G. A Modified Poisson Regression Approach to Prospective Studies with Binary Data. *Am J Epidemiol*. 2004; 159:702–6.10.1093/aje/kwh090 [PubMed: 15033648]
42. Robins JM, Hernán MA, Brumback B. Marginal structural models and causal inference in epidemiology. *Epidemiology*. 2000; 11:550–60.10.1097/00001648-200009000-00011 [PubMed: 10955408]
43. Cole SR, Hernán MA. Constructing inverse probability weights for marginal structural models. *Am J Epidemiol*. 2008; 168:656–64.10.1093/aje/kwn164 [PubMed: 18682488]
44. Troy LM, Hunter DJ, Manson JE, Colditz GA, Stampfer MJ, Willett WC. The validity of recalled weight among younger women. *Int J Obes Relat Metab Disord*. 1995; 19:570–2. [PubMed: 7489028]

Figure 1. Hypothetical causal model

Solid arrows represent pathways by which childhood abuse is hypothesized to influence weight status. The combined impact through all of these arrows is the “total effect”. The “controlled direct effect” (CDE) refers to any remaining influence of childhood abuse on weight change through pathways that do not operate through stress-related eating (that is, through the solid arrows labeled CDE). Dashed arrows represent connections between variables of interest that operate solely through confounding. “Confounders” influence both childhood abuse and weight status; hypothesized confounders include age, race, perceived social status, maternal early adult weight status, and maternal antidepressant use. CDE estimates must also be adjusted for “risk factors” for weight status that might also influence stress-related eating (i.e. they may be confounders of the eating behavior–weight status association); hypothesized risk factors include participant smoking, dieting, physical activity, and participant depression score. *Note that marginal structural models allow for adjustment of the confounding influence of risk factors without blocking the childhood abuse–weight status pathway that operates through those factors.*

Distribution of study sample (number and % of total sample) by type and severity^a of abuse victimization in childhood (age < 11 years).

Table 1a

Physical abuse → Sexual abuse	Emotional abuse category									
	Least abusive			More abusive			Most abusive			
	None n (%)	Mild n (%)	Severe n (%)	None n (%)	Mild n (%)	Severe n (%)	None n (%)	Mild n (%)	Severe n (%)	
None	2325 (54.1%)	193 (4.5%)	22 (0.5%)	535 (12.4%)	384 (8.9%)	132 (3.1%)	63 (1.5%)	103 (2.4%)	188 (4.4%)	
Touch only	113 (2.6%)	12 (0.3%)	4 (0.1%)	33 (0.8%)	32 (0.7%)	7 (0.2%)	1 (0%)	10 (0.2%)	22 (0.5%)	
Forced sex	42 (1.0%)	6 (0.1%)	3 (0.1%)	18 (0.4%)	17 (0.4%)	7 (0.2%)	3 (0.1%)	4 (0.1%)	20 (0.5%)	

^a Bold cell represents participants who reported no abuse prior to age 11 years. Shaded cells represent those who experienced one type of severe abuse (lighter shading) or 2 or more types of severe abuse (darker shading) prior to age 11 years.

Table 1b

Distribution of covariates, eating behaviors, and BMI in early adulthood (age 22–29 years) across abuse exposure in childhood (age < 11 years)

Variable	Abuse in childhood (age<11 years)									
	Physical abuse			Sexual abuse			Emotional abuse			
	None (n=3139)	Mild (n=763)	Severe (n=409)	None (n=3961)	Touched only (n=237)	Forced sex (n=120)	Least abusive (n=2741)	More abusive (n=1172)	Most abusive (n=415)	
	Mean (SD) or column %	Mean (SD) or column %	Mean (SD) or column %	Mean (SD) or column %	Mean (SD) or column %	Mean (SD) or column %	Mean (SD) or column %	Mean (SD) or column %	Mean (SD) or column %	
Outcome: BMI (kg/m ²) at age 22–29 years	24.3 (5.3)	24.5 (5.3)	25.5 (6.0)	24.4 (5.3)	24.8 (5.4)	26.6 (7.0)	24.1 (5.2)	24.8 (5.5)	25.7 (6.2)	
Exposure-outcome covariates:										
Baseline (1996) age (years)	12.1 (1.6)	12.0 (1.6)	12.0 (1.6)	12.0 (1.6)	12.1 (1.6)	12.1 (1.6)	12.0 (1.6)	12.1 (1.6)	12.0 (1.6)	
Baseline BMI percentile ^a , age 9–14 years	55.6 (30.1)	54.3 (30.7)	58.9 (30.3)	55.6 (30.2)	57.3 (29.6)	58.0 (30.4)	55.1 (29.9)	56.3 (30.9)	59.4 (30.2)	
Maternal BMI at age 18 ^b	20.9 (2.8)	21.0 (2.7)	21.1 (2.8)	20.9 (2.8)	20.9 (2.7)	21.5 (2.8)	20.8 (2.7)	21.1 (2.9)	21.3 (3.2)	
Social status score ^c	3.8 (1.1)	4.0 (1.1)	4.0 (1.2)	3.9 (1.1)	4.0 (1.1)	4.3 (1.1)	3.8 (1.1)	4.0 (1.2)	4.1 (1.2)	
Nonwhite race	2.7%	3.1%	4.0%	2.9%	3.6%	3.0%	2.9%	3.4%	2.6%	
Maternal antidepressant use ^d	21.1%	24.8%	31.0%	21.8%	26.7%	37.7%	21.0%	24.5%	27.4%	
Mediators:										
History of any binge eating, 2010	33.3%	40.2%	49.8%	34.9%	51.1%	47.7%	31.8%	41.3%	52.5%	
Coping-motivated eating, 2010:										
Quartile 1	32.5%	26.6%	28.0%	31.8%	28.1%	24.4%	33.0%	28.6%	27.4%	
Quartile 2	26.5%	25.8%	21.0%	26.1%	23.8%	17.7%	27.0%	24.8%	21.5%	
Quartile 3	20.5%	21.2%	20.1%	20.4%	18.9%	24.0%	20.4%	20.7%	19.2%	
Quartile 4	20.5%	26.4%	30.8%	21.8%	29.2%	34.0%	19.6%	25.9%	31.9%	
Mediator-outcome covariates:										
Ever dieted, 2005	75.1%	77.1%	80.1%	75.3%	84.5%	75.5%	74.2%	77.4%	83.9%	
Physically active ^e , 2005	22.8%	25.9%	21.0%	23.3%	23.8%	18.1%	22.6%	24.7%	23.7%	
Ever smoked, 2007	51.6%	54.2%	68.4%	51.8%	64.8%	76.6%	50.0%	56.9%	65.7%	
Depression score, 2007 ^f	7.6 (4.7)	9.2 (5.1)	10.3 (5.4)	8.0 (4.9)	9.4 (5.1)	11.3 (5.5)	7.4 (4.6)	9.1 (5.0)	10.5 (5.6)	

^aRelative to CDC reference growth data [36]

^bMaternal body-mass index at age 18 was reported by participants’ mothers, who are participants in the Nurses’ Health Study II; maternal self-report of age-18 BMI shows good agreement with nursing school medical records [44]

^cAverage of participant’s and mother’s reports of social status in American society (range 1–10 with 1 being highest status)

^dMothers’ report of their history of antidepressant use in or prior to 2001

^eAveraged 10 or more hours of physical activity per week

^fCenters for Epidemiologic Studies Depression Scale—short form[40]; a score of 10 or greater is considered a marker of significant depressive symptoms. The prevalence of significant depressive symptoms ranged from approximately 30% among women with no abuse, to approximately 50% among women with severe abuse.

BMI at age 22–29, social status score, % binge eating, coping-motivated eating, % smoking, and depression score differed significantly (p<0.05) by severity level for all abuse types. Dieting prevalence differed significantly by sexual abuse severity. Baseline BMI percentile and maternal BMI at age 18 differed significantly by emotional abuse severity.

Estimated total effects of physical, sexual, and emotional abuse in childhood (age < 11 years) years on body mass index (kg/m²) in early adulthood (age 22–29 years)

Table 2a

Abuse exposure:	n ^a (mean BMI in kg/m ²)	Model											
		Model 1: Crude		Model 2: Model 1 + age and race ^b		Model 3: Model 2 + mother's BMI at age 18 years ^c		Model 4: Model 3 + social status ^d		Model 5: Model 4 + mother's history of antidepressant use ^e		Model 6: Model 5 + baseline BMI ^f	
		BMI	95% CI	BMI	95% CI	BMI	95% CI	BMI	95% CI	BMI	95% CI	BMI	95% CI
Physical abuse													
None	3139 (24.3)	0	REF	0	REF	0	REF	0	REF	0	REF	0	REF
Mild	763 (24.6)	0.21	(−0.22, 0.65)	0.22	(−0.22, 0.65)	0.15	(−0.28, 0.58)	0.08	(−0.35, 0.52)	0.06	(−0.37, 0.49)	0.18	(−0.27, 0.62)
Severe	409 (25.7)	1.30	(0.68, 1.93)	1.28	(0.66, 1.90)	1.20	(0.58, 1.82)	1.14	(0.52, 1.75)	1.16	(0.53, 1.79)	0.74	(0.15, 1.33)
Sexual abuse													
None	3961 (24.4)	0	REF	0	REF	0	REF	0	REF	0	REF	0	REF
Touch only	237 (24.7)	0.35	(−0.41, 1.11)	0.30	(−0.45, 1.05)	0.25	(−0.49, 0.99)	0.24	(−0.50, 0.99)	0.12	(−0.59, 0.83)	−0.10	(−0.78, 0.58)
Forced sex	120 (25.6)	1.22	(−0.01, 2.45)	1.23	(0.01, 2.45)	0.85	(−0.32, 2.02)	0.78	(−0.35, 1.92)	0.73	(−0.42, 1.88)	0.69	(−0.46, 1.83)
Emotional abused													
Least abusive	2741 (24.1)	0	REF	0	REF	0	REF	0	REF	0	REF	0	REF
More abusive	1172 (24.9)	0.72	(0.34, 1.10)	0.70	(0.32, 1.08)	0.57	(0.19, 0.95)	0.48	(0.10, 0.86)	0.46	(0.07, 0.84)	0.39	(0.01, 0.78)
Most abusive	415 (25.8)	1.70	(1.06, 2.35)	1.71	(1.06, 2.36)	1.45	(0.80, 2.09)	1.40	(0.75, 2.05)	1.37	(0.72, 2.02)	0.85	(0.24, 1.45)

^a Analysis sample size=4377; small differences in total sample size across abuse types are due to exclusion of individuals missing information on that type of abuse.

^b Models adjusted for age in years (continuous), race (white vs nonwhite)

^c Self-reported by mothers, who are NHSII participants (continuous)

^d Perceived social status (average of participant and her mother's perceived social status; continuous with a squared term)

^e Self-reported by mothers, who are NHSII participants (yes/no)

^f Body mass index percentile based on Centers for Disease Control growth chart [36] (continuous with a squared term)

Covariate-adjusted^a total effect estimates of physical, sexual, and emotional abuse before age 11 years on early adult (age 22–29 years) BMI (kg/m²) with additional adjustment for other types of abuse exposure

Table 2b

Abuse exposure:	Model					
	Adjusted for sexual abuse		Adjusted for physical abuse		Adjusted for emotional abuse	
	BMI	95% CI	BMI	95% CI	BMI	95% CI
Physical abuse						
None	0	REF	--	--	0	REF
Mild	0.17	(-0.27, 0.61)	--	--	0.03	(-0.58, 0.64)
Severe	0.68	(0.09, 1.27)	--	--	0.28	(-0.69, 1.26)
Sexual abuse						
None	--	--	0	REF	0	REF
Touch only	--	--	-0.22	(-0.91, 0.47)	-0.21	(-0.92, 0.50)
Forced sex	--	--	0.52	(-0.63, 1.66)	0.61	(-0.53, 1.74)
Emotional abuse						
Least abusive	0	REF	0	REF	--	--
More abusive	0.37	(-0.08, 0.82)	0.38	(-0.01, 0.76)	--	--
Most abusive	1.03	(-0.09, 2.14)	0.81	(0.20, 1.43)	--	--

^a Adjusted for age in years (continuous), race (white vs nonwhite), perceived social status (average of participant and mother's perceived social status; continuous with a squared term), participant BMI percentile at baseline (continuous with a squared term), mother's self-reported BMI at age 18 (continuous), and mother's self-reported history of antidepressant use (yes/no)

Table 3a

Estimated effects of severe physical, sexual, and emotional abuse prior to age 11 years on 13-year adolescent and early adult weight change in the Growing Up Today Study: total effects and controlled direct effects controlling for history of binge eating

Abuse exposure	n ^a (mean BMI in kg/m ²)	Estimated effect			
		Adjusted total effect ^b		Controlling for history of binge eating ^c	
		BMI	95% CI		
Physical abuse					
None or mild	3594 (24.1)	0	REF	0	REF
Severe	354 (25.4)	0.75	(0.15, 1.35)	0.68	(−0.01, 1.37)
Sexual abuse					
None or mild	3857 (24.2)	0	REF	0	REF
Forced sex	100 (25)	0.74	(−0.48, 1.95)	0.50	(−0.95, 1.95)
Emotional abuse					
Least abusive	2550 (24)	0	REF	0	REF
More abusive	1043 (24.5)	0.32	(−0.06, 0.71)	0.43	(−0.01, 0.88)
Most abusive	371 (25.6)	0.91	(0.28, 1.54)	0.84	(0.16, 1.53)
Joint exposure to severe abuse					
No abuse	2182 (24)	0	REF	0	REF
Mild only	1175 (24.2)	0.10	(−0.28, 0.49)	0.24	(−0.20, 0.67)
1 type severe abuse	363 (24.8)	0.52	(−0.12, 1.15)	0.45	(−0.25, 1.15)
2+ types severe abuse	220 (25.9)	1.09	(0.29, 1.89)	0.95	(0.04, 1.87)

^aModels excluded women who reported binge eating at baseline (n=314) or were missing binge eating information at baseline (n=41) or were missing binge eating–BMI covariates (n=27).

^bModels adjusted for age in years (continuous), race (white vs nonwhite), perceived social status (average of participant and mother's perceived social status; linear with a squared term), participant BMI percentile at 1996 baseline (continuous with a squared term), mother's self-reported BMI at age 18 (continuous), and mother's self-reported history of antidepressant use (yes/no)

^cModels adjusted for total effects covariates plus participant smoking (yes/no), dieting (yes/no), physical activity (indicator for 10+ hours/week), and depression (McKnight [39] or CES-D Short Form[40] score) antecedent to binge eating.

Table 3b

Estimated effects of severe physical, sexual, and emotional abuse prior to age 11 years on 13-year adolescent and early adult weight change in the Growing Up Today Study: total effects, controlled direct effects controlling for coping-motivated eating

Abuse exposure	n ^a (mean BMI in kg/m ²)	Estimated effect		
		Adjusted total effect ^b		Controlling for coping-motivated eating ^c
		BMI	95% CI	
Physical abuse				
None or mild	3703 (24.3)	0	REF	0 REF
Severe	379 (25.6)	0.63	(0.04, 1.23)	0.35 (-0.28, 0.98)
Sexual abuse				
None or mild	3977 (24.4)	0	REF	0 REF
Forced sex	112 (25.8)	0.89	(-0.31, 2.10)	0.83 (-0.41, 2.06)
Emotional abuse				
Least abusive	2609 (24.1)	0	REF	0 REF
More abusive	1096 (24.8)	0.36	(-0.04, 0.76)	0.33 (-0.10, 0.76)
Most abusive	392 (25.8)	0.89	(0.27, 1.51)	0.75 (0.06, 1.44)
Joint exposure to severe abuse				
No abuse	2218 (24.1)	0	REF	0 REF
Mild only	1229 (24.5)	0.22	(-0.18, 0.62)	0.26 (-0.17, 0.70)
1 type severe abuse	392 (25.3)	0.49	(-0.11, 1.09)	0.48 (-0.18, 1.13)
2+ types severe abuse	234 (26.1)	1.08	(0.26, 1.91)	0.76 (-0.15, 1.66)

^aModels excluded those missing coping-motivated eating score (n=222) or coping-motivated eating-BMI covariates (n=29).

^bModels adjusted for age in years (continuous), race (white vs nonwhite), perceived social status (average of participant and mother's perceived social status; continuous with a squared term), participant BMI percentile at 1996 baseline (continuous with a squared term), mother's self-reported BMI at age 18 (continuous), and mother's self-reported history of antidepressant use (yes/no).

^cModels adjusted for total effects covariates plus participant history of smoking through 2007 (yes/no), history of dieting through 2005 (yes/no), physical activity in 2005 (indicator for 10+ hours/week), and depression in 2007 (CES-D Short Form[40] score).